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ANALYSIS OF FATAL ON-DUTY DRIVER-ERROR ACCIDENTS IN THE U.S. ARMY

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INTRODUCTION

In Figure 1 vehicular accidents are found in the following categories: Army motor vehicle (AMV), privately owned vehicle (POV), other - not elsewhere coded (OTHE-NEC), and tracked vehicle (TRACK). It can be seen that vehicular accidents form the Army's largest accident problem in terms of number and cost.

The purpose of this study was to perform an in-depth analysis of vehicle accident cause factors. Since analytic resources were limited, it was decided to focus on vehicular accidents that:

(a) were Army-responsible in terms of accountability and prevention; and

(b) had the best information in terms of quality and quantity.

It was decided to select on-duty vehicular accidents because the Army is clearly responsible for them. From these on-duty accidents, those which resulted in a fatality were selected because their reports were expected to have better information than reports of less severe accidents. Also, the number of fatal on-duty accidents was small enough to permit a cause-factor analysis of each report. It was expected that drivers would be frequently cited as accident cause factors so the analysis was directed toward driver error.

METHOD

Table 1 reveals there were 194 fatal on-duty accidents during 1976 and 77. Of these, 13 reports had insufficient information to determine whether or not a driver error occurred. Of the remaining 181, 131 (72%) were found to have driver error as a cause factor.

Table 2 shows variables that were found to be important in describing the accident situation. Table 3 shows the variables used to describe *what* happened (unsafe act), *what* caused it to happen (unsafe personal factor) and *what* to do about it (corrective actions). In this 3W cause-factor analysis, for each driver error (unsafe act), one or more unsafe personal factors was identified, and for each unsafe personal factor, one or more corrective actions was recommended.

Statistical Analyses. To measure relationships between accident and 3W variables the Jaccard coefficient (J) (Anderberg, 1973, p. 89) was selected:

$$J = \frac{a}{a+b+c}$$

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where: a = simultaneous occurrence of variable 1 and variable 2,

b = occurrence of variable 1 without variable 2, and

c = occurrence of variable 2 without variable 1.

J is interpreted as the conditional probability that a randomly chosen case will have variable 1 and 2 present, given that cases without either variable are treated as irrelevant.

Factor Analysis. The first type of analysis these data were subjected to was factor analysis. The objective was to identify the fewest factors that represented the largest part of the driver-error problem. Table 4 presents the accident and driver error (unsafe act) variables selected for factor analysis. Since nothing was known about the expected frequency of the accident and driver error (unsafe act) variables, an arbitrary selection criterion was used, i.e., each variable selected occurred in at least 7% of the cases (cases = drivers committing errors that caused an accident = 133). Table 5 shows the simultaneous occurrences of these variables and Table 6 shows their Jaccard coefficients. It should be noted that variables *A1* and *A10* were eventually eliminated from the factor analysis. It was found that they did not help define a factor and occurred such a large number of times that they only added confusion to the analysis.

A maximum likelihood component analysis with varimax rotation (Dixon, 1975, pp. 371-372) was applied to the Jaccard matrix to indicate the number of factors to extract. A maximum likelihood solution with communality estimates from a centroid solution (Horst, 1965, p. 599) and with varimax rotation was used to extract the indicated number of factors. A factor scores analysis (Dixon, 1975, p. 373) was performed to identify each case with a factor. This categorization of cases permitted the analysis of accident report information to help interpret the factors. The categorization was validated by an individual review of each accident report to insure that each case belonged to the factor to which it had been categorized.

3W Analysis. The categorization of cases by factor also permitted identification of important 3W relationships for each factor. Since there is no known method of determining statistical significance for the Jaccard coefficient, the importance of relationships between 3W variables was arbitrarily determined by the proportionate occurrence and simultaneous occurrence of variables relative to the number of cases in each factor. This information was used to help interpret each factor (Note: complete simultaneous occurrence and Jaccard coefficient matrices for each factor may be obtained on request to the author).

RESULTS

The maximum likelihood component analysis indicated that six factors should be extracted. The centroid estimate of common factor variance was 53%. Table 7 shows that the maximum likelihood solution extracted six factors that accounted

for 86% of the common factor variance and 46% of the total variance. Table 8 presents a number and accident cost summary of the factor scores categorization of cases by factor. Tables 9-20 show the accident report and 3W information that was found important in interpreting the factors.

DISCUSSION

Statistical Analyses. The variance accounted for and the factors extracted by the maximum likelihood solution (Table 7) were considered adequate, especially since little control could be exercised over the quality of the data analyzed, i.e., control over investigation and reporting. The six factors identified were surprisingly satisfactory in that they represented a large part of the driver-error problem, i.e, 95% of the cases and 99% of the cost (Table 8). This representation was validated by the individual accident report review. There were fewer than 10 cases in which the factor categorization was considered questionable.

Factor Interpretation.

Factor I - Improper Passing. Table 9 shows that this factor accounted for 8% of the driver error cases but only 5% of the accident cost (dollar cost of injuries, fatalities, and property damage). This indicates that these accidents were less severe than their proportionate representation. All of these *improper passing* cases involved active duty drivers, 90% occurred off post, 80% occurred in Germany, and 60% involved large trucks. A review of each accident report revealed that 50% of the passing errors involved hazardous road conditions (icy, narrow, pot holes), 30% involved a lack of visual clearance, and 20% involved the passing of buses that were loading/unloading passengers. Table 10 indicates the drivers did not appreciate the hazards and suggests training as a corrective action.

Factor II - Improper turning. Table 11 reveals that this factor accounted for 12% of the cases but only 8% of the accident cost. This indicates that these accidents were less severe than their proportionate representation. Most (63%) of these accidents occurred off post and involved a failure to yield the right of way (40%) or an over-reactive turn (33%). The other driver errors involved improper U-turns (13%) and excessive control pressures on track vehicles (13%). Fatigue may have played an important role in causing these driver errors as evidenced by the 10.1 average hours on duty. Table 12 indicates the drivers were inattentive, did not appreciate the hazard, willfully disregarded laws, were inadequately trained and suggests improved instruction as a corrective action.

Factor III - Excessive speed. Table 13 shows this factor accounted for 38% of the cases but 48% of the accident cost. This indicates that these accidents were much more severe than their proportionate representation. The disproportionate severity of these accidents is attributed primarily to the vehicle overturning (70%) and only secondarily to excessive speed (98%). A review of the accident reports indicated that in most cases the speed was not absolutely excessive, but excessive for the existing conditions.

Those conditions mainly involved slippery (wet, gravel, icy), inclined (mostly down), and curving roads/surfaces. The accident locations were roughly equally divided between on and off post as were the unsafe road or surface conditions between paved and dirt. A relatively large number (36%) of these *excessive speed* cases occurred during field maneuvers. Table 14 indicates that most of the *excessive speed* driver errors were due to willful disregard of instructions, indifference or not appreciating the hazard. Training and instruction were the most frequently recommended corrective actions.

Factor IV - Unsafe mechanical conditions. Table 15 reveals that this factor accounted for 8% of the cases but 10% of the accident cost. This indicates that these accidents were slightly more severe than their proportionate representation. A review of the accident reports indicated that of the unsafe mechanical conditions, 45% involved brakes and 36% involved tires/track block. Table 16 shows that four of the driver errors concerned inadequate inspection and were caused by not appreciating the hazard. Training and improved instruction were the most frequently cited corrective actions.

Factor V - Unsafe road conditions. Table 17 shows that this factor accounted for 18% of the cases but 22% of the accident cost. This indicates that these accidents were more severe than their proportionate representation. The disproportionate severity of these accidents is attributed primarily to the vehicle overturning (50%) after encountering hazardous road/surface conditions. These conditions mainly involved slippery (wet, icy, mud), inclined (mostly down), or soft shouldered roads/surfaces. Most (71%) of these accidents occurred on post and on dirt surfaces. Almost half (11) of the driver errors concerned improper safety precautions for operations on or near hazardous terrain. Table 18 indicates that most of these errors were due to not appreciating the hazard or being unaware of safe practices. Training, improved instruction and procedural revision were the most frequent corrective actions suggested.

Factor VI - Night/excessive duty hours. Table 19 reveals that this factor accounted for 12% of the cases but only 6% of the accident cost. This indicates that these accidents were much less severe than their proportionate representation. Most (88%) of these accidents occurred at night and off post (81%). Half (50%) involved jeeps and 38% occurred in Korea. The 14.4 average hours on duty suggests that fatigue played an important role in these driver-error accidents. Table 20 shows that inattention and not appreciating the hazard were cited in most cases with improved instruction most frequently suggested as the corrective action.

CONCLUSIONS

A large proportion (72%) of fatal on-duty vehicle accidents which occurred during 1976 and 77 involved driver error as a cause. Of the variables used in analyzing these accidents (Table 4), those describing the accident situation played a large part in the six factors that were extracted by the factor

analysis. This is a clear indication of the importance that the interaction between hazardous situations and driver error has in the occurrence of accidents.

Variable A7 *Overturned* was important in defining the two factors (III and V) with the greatest severity in terms of fatalities and cost. Also, since A7 *Overturned* occurred in 65 (49%) of the cases, it appears that overturning is highly related to the production of fatal injuries in the vehicular accidents studied.

Variable A9 *Hours on duty* > 8 was important in defining two factors (II and VI) where fatigue was suspected of causing driver errors. Fatigue may have had a more pervasive impact on driver error than indicated in these two factors since A9 *Hours on duty* > 8 occurred in 34 (26%) of all cases and the average hours on duty at the time of the accident was 7.4 for all drivers committing errors.

Coupled with the 3W information, the six factors reveal important driver-error problems and suggest corrective actions. Work is presently underway to identify specific corrective actions that can be cost-effectively applied.

Finally, better accident information is required and efforts are being made to provide this information by revising the accident investigation and reporting system. For example, the 3W variables are only categorical data and need to be revised to provide specific statements concerning task errors (*what* happened), system inadequacies (*what* caused it to happen) and remedial measures (*what* to do about it).

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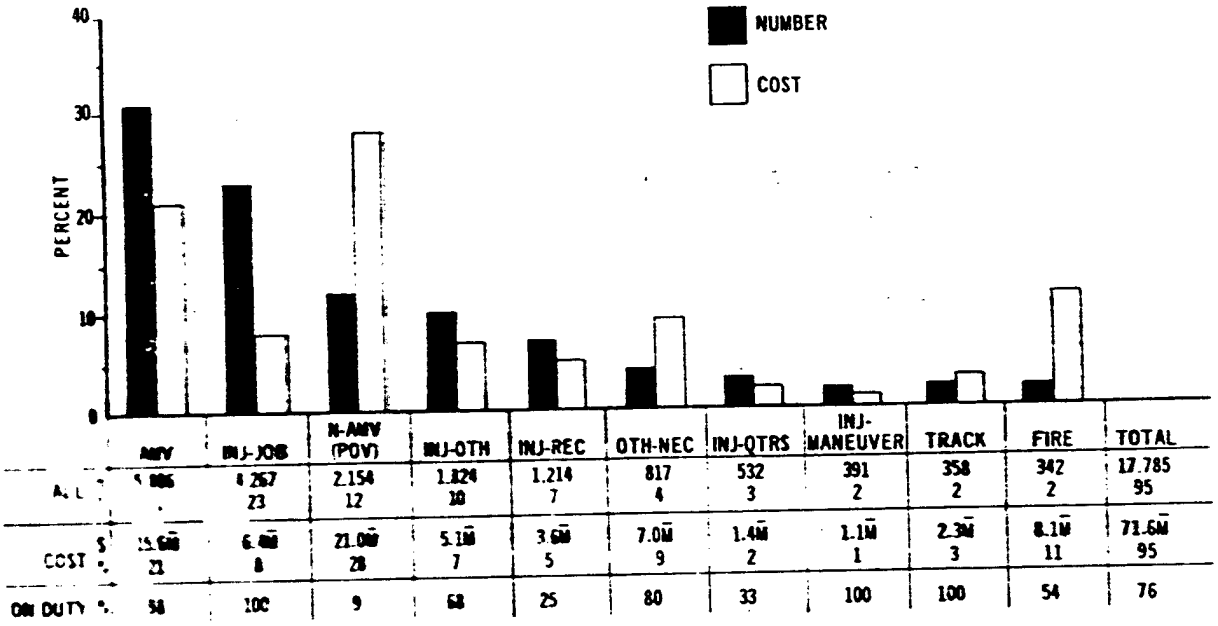

	AMV	INJ-JOB	N-AMV (POV)	INJ-OTH	INJ-REC	OTH-NEC	INJ-QTRS	INJ-MANEUVER	TRACK	FIRE	TOTAL
ALL #	1 806	1 267	2.154	1.824	1.214	817	532	391	358	342	17.785
	23	23	12	10	7	4	3	2	2	2	95
COST $	15.6M	6.4M	21.0M	5.1M	3.6M	7.0M	1.4M	1.1M	2.3M	8.1M	71.6M
	21	8	28	7	5	9	2	1	3	11	95
ON DUTY %	58	100	9	68	25	80	33	100	100	54	76

FIGURE 1. NUMBER AND COST OF THE 10 MOST FREQUENT TYPES OF ACCIDENTS IN CY 77

TABLE 1
CY 76 AND 77 FATAL ON-DUTY VEHICLE ACCIDENTS

	AMV ACTIVE	TRACK	OTHER AMV N.E.C.	AMV N.G.	POV ON-POST	TOTAL
DRIVER ERROR	96	17	10	5	3	131
NO DRIVER ERROR	31	15	1	2	1	50
INSUFFICIENT INFORMATION	7	2	1	2	1	13
						194

TABLE 2
ACCIDENT VARIABLES

n	%	VARIABLES
102	77	1. AMV
18	14	2. ARMY TRACK VEHICLE
10	8	13. OTHER AMV N.E.C.
3	2	17. NON-ARMY MV-POV, ON POST, DRIVER ON DUTY
25	19	3. NIGHT
3	2	4. WEATHER–ANY CONDITION AFFECTING VEHICLE CONTROL OR OPERATOR VISIBILITY
53	40	5. ROAD SURFACE–ANY CONDITION AFFECTING VEHICLE CONTROL OR OPERATOR VISIBILITY
15	11	6. UNSAFE MECHANICAL/PHYSICAL CONDITION–AFFECTING VEHICLE CONTROL OR OPERATOR VISIBILITY
65	49	7. OVERTURNED
22	17	8. VEHICLE IN CONVOY
34	26	9. HOURS ON DUTY (ONLY IF IN EXCESS OF EIGHT)
73	55	10. DIRECTION OF MOTION–FORWARD
5	4	11. DIRECTION OF MOTION–BACKWARD
18	14	12. DIRECTION OF MOTION–FORWARD, TURNING
6	5	14. DIRECTION OF MOTION–HALTED/PARKED
21	16	15. DIRECTION OF MOTION–FORWARD/NEGOTIATING CURVE
10	8	16. DIRECTION OF MOTION–FORWARD/PASSING

TABLE 3
3W TYPE VARIABLES

n	%	UNSAFE ACTS
61	43	1. Excessive speed N.E.C.
3	2	2. Driving in wrong lane crossing centerline
1	1	3. Using improper tools equipment
22	16	4. Starting operating without taking proper safety precautions
3	2	5. Sleeping when wakefulness is necessary
11	8	6. Improper turning
2	1	7. Personal action of unsafe nature N.E.C.
8	8	8. Failure to maintain control
8	6	9. Unsafe use of equipment tools machines etc.
1	1	10. Distracted involved in horseplay practical joking etc.
4	3	11. Failing to lock block secure machines equipment, etc.
3	2	12. Operating without authority etc. N.E.C.
10	7	13. Improper passing
4	3	14. Following too closely
6	4	15. Lack of adequate inspection testing, etc.
1	1	16. Using unsafe equipment etc., N.E.C.
1	1	17. Failure to obey regulatory traffic signals devices
141	101	TOTAL

n	%	UNSAFE PERSONAL FACTORS
21	13	1. Willful disregard of instructions (laws, orders, etc.)
6	4	2. Reckless show-off braggart etc.
7	4	3. Did not recognize hazard
4	3	4. Inadequate experience
14	9	5. Indifferent inattentive unobservant absent-minded, etc.
71	45	6. Did not appreciate hazard
10	6	7. Unaware of safe practices
4	3	8. Lack of knowledge still experience N.E.C.
8	5	9. Inadequately trained
6	4	10. Fatigued
4	3	11. Had been drinking alcoholic beverages
1	1	12. Improper attitude
2	1	13. Failure to understand verbal or written orders rules laws, etc.
158	101	TOTAL

n	%	CORRECTIVE SUPERVISORY MANAGERIAL ACTIONS
46	24	1. Training (individual supervisor group etc.)
54	28	2. More or improved instruction
25	13	3. Improved supervision
1	1	4. Use of proper equipment material
20	10	5. Procedural revision (procedure arrangement revised etc.)
15	8	6. Personnel adjustment–actual or anticipated (reassignment etc.)
11	6	7. Counseling
3	2	8. To attend DDC
10	5	9. Judicial action pending
7	4	10. Persuasion appeal (publish this type accident with printed material)
1	1	11. Engineering revision redesign relocation etc.
193	102	TOTAL

TABLE 4
VARIABLES SELECTED FOR FACTOR ANALYSIS

n	ACCIDENT VARIABLES
90	1. AMV
19	2. ARMY TRACK VEHICLE
10	13. OTHER AMV N.E.C.
25	3. NIGHT
53	5. ROAD/SURFACE CONDITION
15	6. UNSAFE MECHANICAL CONDITION
65	7. OVERTURNED
22	8. VEHICLE IN CONVOY
34	9. HOURS ON DUTY -8
73	10. FORWARD
18	12. TURNING
21	15. NEGOTIATING CURVE
10	16. PASSING

n	UNSAFE ACT VARIABLES (driver error)
61	1. EXCESSIVE SPEED
22	4. STARTING/OPERATING WITHOUT TAKING PROPER SAFETY PRECAUTIONS
11	6. IMPROPER TURNING
10	13. IMPROPER PASSING

TABLE 5
SIMULTANEOUS OCCURRENCES MATRIX

VARIABLES	A2	A3	A5	A6	A7	A8	A9	A12	A13	A15	A16	T1	T4	T6	T13
A2	18*	3	11	2	13	7	5	4		2		6	4	2	
A3		25	8	2	8	3	15	5	2	3		11	5	3	
A5			53	4	39	15	15	4	4	13	4	25	14	1	5
A6				15	9	4	4		3	2		2	5		
A7					65	18	18	7	6	16	4	38	11	2	3
A8						22	5	1		6	2	11	3		2
A9							34	8	1	6		16	6	4	
A12								18				5		10	
A13									10			3	3		
A15										21		16		1	1
A16											10	2			9
T1												61			1
T4													22		
T6														11	
T13															10

*Boxes indicate number of times each variable occurred.

TABLE 6
JACCARD COEFFICIENT MATRIX

VARIABLES	A2	A3	A5	A6	A7	A8	A9	A12	A13	A15	A16	T1	T4	T6	T13
A2		.07	.18	.06	.19	.21	.11	.13		.05		.08	.11	.07	
A3			.11	.05	.10	.07	.34	.13	.06	.07		.15	.12	.09	
A5				.06	.49	.25	.21	.06	.07	.21	.07	.28	.23	.02	.09
A6					.13	.12	.09		.14	.06		.03	.16		
A7						.26	.22	.09	.09	.23	.06	.43	.14	.03	.04
A8							.10	.03		.16	.07	.15	.07		.07
A9								.18	.02	.12		.20	.12	.10	
A12												.07		.53	
A13												.04	.10		
A15												.24		.03	.03
A16												.03			.82
T1															.01
T4															
T6															
T13															

TABLE 7
ROTATED MAXIMUM LIKELIHOOD FACTOR MATRIX*

VARIABLES	FACTORS I	II	III	IV	V	VI
T13. IMPROPER PASSING	.99					
A16. PASSING	.82					
A12. TURNING		.99				
T6. IMPROPER TURNING		.53				
T1. EXCESSIVE SPEED			.68			
A7. OVERTURNED			.63		.39	
A5. ROAD/SURFACE CONDITION			.42		.57	
A15. NEGOTIATING CURVE			.35			
A8. VEHICLE IN CONVOY			.25		.26	
A6. UNSAFE MECHANICAL CONDITION				.99		
T4. IMPROPER SAFETY PRECAUTIONS					.40	
A2. TRACK VEHICLE					.27	
A3. NIGHT						.73
A9. HOURS ON DUTY >8						.41
A13. OTHER AMV N.E.C.						
COMMON VARIANCE (PERCENT)	27	16	16	13	11	9 = 86
TOTAL VARIANCE (PERCENT)	11	9	9	7	6	5 = 46

*FACTOR LOADINGS <.25 ARE OMITTED TO FACILITATE FACTOR INTERPRETATION.